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Materiel Test Procedure 6-2-189
Electronic Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

METEOROLOGICAL EQUIPMENT, WIND MEASURING, SURFACE

1. OBJECTIVE

The objective of this Materiel Test Procedure is to describe the engineering tests required to determine the technical performance, engineering adequacy, and technical characteristics of equipments designed to measure the significant parameters of surface winds relative to the requirements of applicable Qualitative Materiel Requirements (QMR), Small Development Requirement (SDR), Technical Characteristics (TC), or other applicable documentation.

2. BACKGROUND

Accurate and timely knowledge of surface wind conditions existing at key points in a tactical operations area is a necessary integrant of the meteorological data required in many aspects of land warfare. "Surface wind" is arbitrarily defined as the natural movement of air over open, level terrain at heights up to about 15 meters above the surface. The significant wind parameters to be measured are the speed and direction and the variability of each, i.e., short term or sudden changes (gustiness) and long term or diurnal changes.

Wind measuring equipments used in Army field operations vary in configuration and complexity in accordance with the requirements of specific applications. They range from relatively simple, hand-held, direct-reading instruments for spot measurements to the more accurate, remote indication/recording systems employed at semi-fixed meteorological stations and certain artillery positions. The basic design and method of operation of some commonly used equipments are described in Appendix B. A generic form of wind measuring set considered as the test item model for this procedure is described in paragraph 6.1.

New wind measuring equipment developed in response to new requirements or to incorporate improved features must be tested to determine the technical performance characteristics and suitability of the item for service testing.

3. REQUIRED EQUIPMENT

a. Low-speed wind tunnel or equivalent facility.
b. Laboratory standard air-flow measuring instrument (part of a. above) or equivalent calibrated wind speed measuring set to provide a reference standard.
c. Laboratory standard compass.
d. Stopwatch.
e. Electrical/electronic test equipment as required for test item alignment and maintenance.
f. Camera, motion picture and still.

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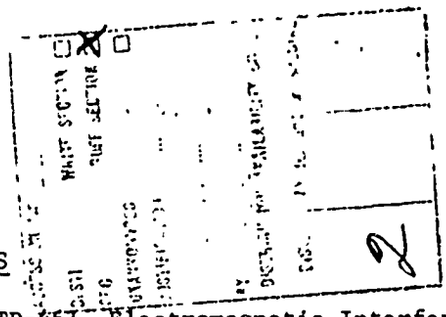

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N. AMCR 385-12, Verification of Safety of Materiel from Development through Testing, Production, and Supply to Disposition.
O. MTP 3-1-002, Confidence Intervals and Sample Size.
P. MTP 6-2-185, Meteorological Sounding Systems.
Q. MTP 6-2-507, Safety.
R. MTP 10-2-501, Operator Training and Familiarization.
S. MTP 10-3-500, Preoperational Inspection and Physical Characteristics.

5. SCOPE

This document encompasses surface wind measuring equipments contemplated primarily for use in field army operations.

5.1 SUMMARY

5.1.1 Technical Characteristics

a. The procedure describes in general terms the engineering tests required to determine the technical performance characteristics of wind speed and wind direction measuring equipment designed for use as a complete end item or as the wind measuring element of a field-type meteorological station.

b. The performance tests outlined below are conducted in a form of wind tunnel facility incorporating controllable air flow and calibrated air flow measuring instrumentation.

1) The wind speed components of the test item are tested for accuracy, response, and repeatability under accurately established conditions of air speed throughout the design range of the test item.

2) The wind direction components of the test item are tested for accuracy, response, repeatability, and stability under various conditions of tunnel air speed and sensor-air stream positional relationship.
3) The above tests are repeated, as appropriate, with the components of several test item sets interchanged in order to check component compatibility or identify sources of error.

c. Test item ancillary equipment such as sensor support masts are tested in accordance with the provisions of the applicable MTP and/or the QMR/SDR.

5.1.2 Common Engineering Tests

Not included in this MTP are the following common engineering tests which are applicable to these commodities:

a. MTP 6-2-500, Physical Characteristics.
b. MTP 6-2-502, Human Factors Engineering.
c. MTP 6-2-503, Reliability.
d. MTP 6-2-504, Design for Maintainability.
e. MTP 6-2-507, Safety.
f. MTP 6-2-514, Electrical Power Requirements.
g. MTP 6-2-520, Transportability of Communication, Surveillance, and Electronic Equipment.
h. MTP 6-2-530 through MTP 6-2-541, Environmental Tests.

NOTE: Supplemental information is contained in the following appendices:

1) Appendix A - "Speed Conversion Factors".
2) Appendix B - "Description of Some Contemporary Wind Measuring Equipments".

5.2 LIMITATIONS

a. The procedure is generally limited to portable and transportable wind measuring equipment and sets for field army operations.
b. The procedure excludes consideration of upper atmosphere wind measuring systems; reference is made to MTP 6-2-185.
c. Throughout the procedure, wind speed or air flow is expressed in knots (nautical miles per hour); tables for conversion to/from statute miles per hour (mph) and other units are given in Appendix A. Horizontal direction is expressed in degrees of azimuth relative to a given reference.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Upon establishing the scheduled availability of the test item coordinate the availability of the following:

1) Engineering safety release or other safety statement.
2) Maintenance support facilities, spare parts, and personnel.
3) Equipment, special facilities, and instrumentation with special attention to timely provision of additional supplies or special equipment not readily available at the test site.

b. Select test equipment ideally having an accuracy of at least ten orders of magnitude greater than that afforded by the item under test, that is in keeping with the state of the art, and with calibrations traceable to the National Bureau of Standards.

c. Record the following information:

1) Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.

d. Ensure that all test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).

e. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous similar tests conducted on the same types of equipment. These documents shall be kept readily available for reference.

f. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.

g. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety SOP's are observed throughout the test and that the item has successfully completed MTP 6-2-507, Safety.

h. Thoroughly inspect the test item for obvious physical and electrical defects such as cracked or broken insulation, loose connections, bare or broken wires, loose assemblies, bent fragile parts, and corroded plugs and jacks. All defects shall be noted and corrected before proceeding with the test.

i. Prior to beginning any subtest, verify correct power source, necessary test instrumentation and inter-connecting cabling, and that the equipment is aligned, if necessary, as specified in the pertinent operating instructions to ensure, insofar as possible, it represents an average equipment in normal operating condition.

j. Prepare a test item sample plan sufficient to ensure that enough samples of all measurements are taken to provide statistical confidence of final data in accordance with MTP 3-1-002. Provisions shall be made for modification of the plan during test progress as may be indicated by monitored test results.

k. Ensure that arrangements for supporting and participating agencies, activities and facilities have been made, that authorization for electromagnetic radiation at specific frequencies, power levels and modulations for required periods has been obtained, that all personnel have been briefed on the purposes of the tests and the results expected, and that appropriate security measures are instituted, as required, to safeguard classified materiel and data.

1. Set up the following test conditions:

NOTE: 1. The example of wind measuring set shown in block diagram form in Figure 1 is considered as the test item model for test description in this MTP.
2. Parameter values cited throughout the procedure are given for illustration only.

Install the detector component(s) of the test item in a wind tunnel or equivalent facility having the following minimal characteristics:

1) A test (working) section of adequate cross-section to:

a) provide an approximate free air stream (negligible wall effects).
b) accomodate the test item.

2) A turntable, in the test section for mounting and positioning the test item with respect to the air stream.
3) A controllable, variable-speed fan to create laminar air flow simulating wind speeds from zero to above the test item range.
4) A means of rapidly fluctuating the air stream in speed and, within tunnel configuration limits, the angle of attack on the test item for simulation of wind gusts.
5) Integral, calibrated air flow measuring instrumentation (reference standard) capable of accurately indicating tunnel air speed in knots or equivalent units throughout the range of interest.

6.2 TEST CONDUCT

NOTE: Prior to the following system tests, the indicator/recorder of at least one test item set shall be calibrated as a standard for use in resolving system anomalies which may develop. Calibrate the selected indicator/recorder with precise values of appropriate input signals over the full ranges of speed and direction in accordance with the prescribed technical specifications for "indication versus input signal". Construct correction curves as necessary. In addition to its system test, utilize the calibrated indicator/recorder as required by paragraphs 6.2.1.1 e., 6.2.2.1 e., and 6.2.3 c.

6.2.1 Speed Tests

6.2.1.1 Accuracy

a. Position the test item impeller in the approximate cross-sectional center of the tunnel test section and lock the turntable to hold the impeller axis (if propeller type) in alignment with the tunnel air stream axis.

b. Activate the tunnel fan and increase the air speed in 5 knot increments, as determined by the reference standard, over the test item range

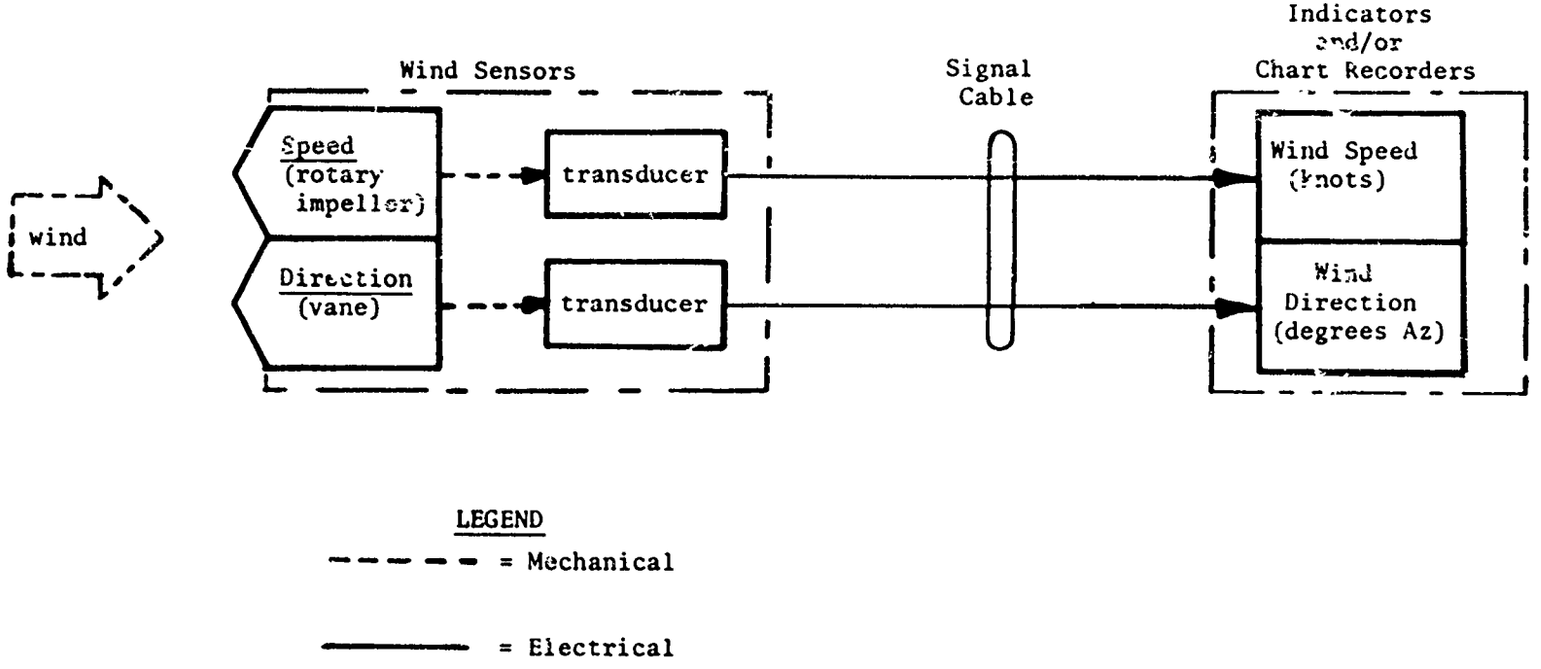

Figure 1. Example of Wind Measuring Set for Test Description

to maximum. Record the reference indicator and test item indicator readings at each step.

c. Decrease the air speed in 5 knot steps to zero and record the reference and test item data as in (b) above.

d. Repeat (b) and (c) above a sufficient number of times to ensure statistically valid test data, e.g., five times.

e. In the event the test data exceeds specified tolerances at any step, substitute the calibrated indicator/recorder noted above for the indicator/recorder under test and repeat the above steps as necessary to determine the source of error, i.e., the sensor or indicator/recorder.

f. During steps (b) and (c) above, observe the test item sensor for evidence of vibration (usually due to a rotational unbalance condition). Measure the frequency and magnitude of observed vibrations by suitable means (e.g. stroboscope or electro-optical instrument; reference MTP 6-2-540) and record the data correlated with the air speeds at which they occur.

6.2.1.2 Response

NOTE: This subtest may be performed in conjunction with the Accuracy Test.

a. Gradually increase tunnel air flow from zero to the rate at which the impeller just starts to rotate. Record the reference and test item indicator readings at the "start" point.

b. Increase the air flow to some rate above the "start" speed and then gradually decrease the air flow until the impeller just ceases to rotate. Record the reference and test item indicator readings at the "stop" point.

c. Repeat steps (a) and (b) a sufficient number of times to determine the average starting and stopping speeds.

d. Simulate gust conditions of pre-selected approximate characteristics, i.e., period, duration, air speed limits, to determine the test item tracking characteristics. Record the reference and test item data by means of auxiliary chart recorders or a motion picture camera encompassing the reference and test item indicators in the same field of view.

6.2.2 Direction Tests

NOTE: 1. The tunnel turntable shall be marked with a peripheral scale of 0-360 degrees and indexed with a pointer affixed to the test section floor at the upstream edge of the table in alignment with the tunnel air flow axis.
2. The direction sensor housing shall be mounted on the turntable so that the vertical axes of the sensor and the turntable are in coincidence and that the north-south axis of the housing is aligned with the 0-180 degree axis of the turntable.

6.2.2.1 Accuracy

a. Establish a steady air flow of 10 knots.
b. Rotate the sensor housing (turntable) in 15 degree steps through

360 degrees in a clockwise direction. Record the test item direction indicator reading at each step.

c. Repeat the above except rotate the table in a counter-clockwise direction.

d. Increase air flow to a steady 20 knots and repeat steps (b) and (c) above.

e. In the event the test data exceeds specified tolerances at any step, substitute the calibrated indicator/recorder noted above for the indicator under test and repeat the above steps as necessary to determine the source of error, i.e., the sensor or indicator/recorder.

6.2.2.2 Response and Stability

a. With no air flow, position the sensor housing at 0 degrees and manually offset the vane to 90 degrees.

b. Initiate and gradually increase air flow until the indicator reads 0 degrees. Record the air speed necessary to move the vane to 0 degrees.

c. Repeat steps (a) and (b) above with the vane initially offset to 270 degrees.

d. With a steady air flow of 10 knots, manually offset and hold the vane at 50 degrees. Release the vane and observe/record the indicated degree of overshoot (and number of oscillations, if any) before streamlining at 0 degrees.

e. Repeat step (d) above except offset and hold the vane at 310 degrees.

f. Repeat steps (d) and (e) above at an air speed of 20 knots.

g. With the vane streamlined, increase air flow in 10 knot increments from zero to test item maximum. Observe for indication of oscillation or vibration at each step. Measure and record the magnitude and approximate frequency of observed oscillations or vibrations and the air speed at which they occurred.

6.2.3 Component Interchangeability

NOTE: This subtest is intended solely as a spot check of the ability of replacement components (sensors, indicators, or recorders) to function in an operational system without modification or high order calibration. This subtest requires the availability of at least three complete test items.

a. Ensure that the components of the original test item sets are suitably identified by serial number or arbitrary designation.

b. Interchange like components in all possible combinations to produce complete test item sets having different component arrangements.

c. Observe and record any difficulties in performing this interchange.

d. Perform the wind speed and direction accuracy tests of paragraphs 6.2.1.1 and 6.2.2.1 on each combination. Record the test data and associated component identification designations of each combination.

6.2.4 Electromagnetic Interference (EMI) Tests

Perform the electromagnetic interference tests prescribed by the test directive or equivalent document in accordance with the applicable provisions of MIL-STD-461 and -462.

6.2.5 Common Engineering Tests

Perform the common engineering tests prescribed by the test directive or equivalent document in accordance with the applicable MTP's (reference paragraph 5.1.2).

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include but not be limited to:

a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.

b. Nomenclature, serial number, accuracy tolerance, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Damages to the test item(s) incurred during transit and/or manufacturing defects.

6.3.2 Test Conduct

Data to be recorded in addition to specific instructions listed below for each subtest shall include:

a. A block diagram of the test setup employed in each specified test. The block diagram shall identify by model and serial number, all test equipment and interconnections (cable lengths, connectors, attenuators, etc.) and indicate control and dial settings where necessary.

b. Photographs or motion pictures (black and white or color), sketches, charts, graphs, or other pictorial or graphic presentation which will support test results or conclusions.

c. An engineering logbook containing, in chronological order, pertinent remarks and observations which would aid in a subsequent analysis of the test data. This information may consist of descriptions of equipment or components, and functions and deficiencies, as well as theoretical estimations, mathematical calculations, test conditions, intermittent or catastrophic failures, test parameters, etc., that were obtained during the test.

d. Test item sample size (number of measurement repetitions).

e. Instrumentation or measurement system mean error stated accuracy.

6.3.2.1 Speed Tests

a. Accuracy

1) Record the air speed (knots) indicated by the reference standard and the test item at each ascending and descending step.
2) Record the data for each repetitive series.
3) If applicable, record component out-of tolerance data, e.g., component, range step, sign and magnitude of error, and criterion.
4) If applicable, record the frequency and magnitude of observed vibrations and the air speeds at which they occurred.

b. Response

1) Record the reference and test item indicator readings (knots) at the impeller starting and stopping points.
2) Record the results of each series.

c. Gust Test

1) Record the planned gust characteristics (as indicated by reference standards), i.e., number of gusts per second or minute, duration (seconds), and upper and lower air speeds (knots).
2) Record the test item response to the above in like units.

6.3.2.2 Direction Tests

a. Accuracy

1) Record the test item indicator reading (degrees) at each clockwise and counter-clockwise step for the 10 and 20 knot air speed conditions.
2) If applicable, record component out-of-tolerance data, e.g., component, range step, sign and magnitude of error, and criterion.

b. Response and Stability

1) Record the offsets (degrees) and the associated minimum air speed (knots).
2) Record the offsets (degrees) and the associated overshoots (degrees) under the 10 and 20 knot air speed conditions.
3) Record the magnitude (degrees total swing) and frequency (cycles per second) of oscillations and the air speed (knots) at occurrence; record negative results.

6.3.2.3 Component Interchangeability

a. List the test item configurations as identified by component combination.

b. Record the speed and direction accuracy test data derived from

each configuration (reference paragraphs 6.3.2.1.a. and 6.3.2.2.a.).

6.3.2.4 Electromagnetic Interference (EMI) Tests

Record the test data in accordance with the applicable provisions of MIL-STD-461, MIL-STD-462 and MIL-STD-463.

6.3.2.5 Common Engineering Tests

Record the test data obtained in each subject test in accordance with the applicable MTP.

6.4 DATA REDUCTION AND PRESENTATION

The data obtained from the technical performance subtests shall be statistically reduced and summarized to show the mean and distribution of values of each parameter for the total test. Presentation shall be made in tabular and graphic form with the control data (reference values) and performance criteria included in a comparative manner. The composite data shall be accompanied by the detailed test data on each test item set.

Test data derived from the EMI and common engineering tests shall be presented in accordance with the applicable MTP or comparable procedure, appropriately correlated with the basic performance test.

The total data presentation shall be prefaced by, or include as appropriate, a description of the test item, the test facilities, and the sequence of events supplemented with applicable charts, diagrams, and photographs.

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APPENDIX A

SPEED CONVERSION FACTORS

1. Miles/hour - knots

Table A-I

M/h	Knots	M/h	Knots	M/h	Knots
1	0.9	34	31	67	60
2	1.7	35	31	68	61
3	2.5	36	32	69	62
4	3.3	37	33	70	63
5	4.3	38	34	71	64
6	5.2	39	35	72	65
7	6.1	40	36	73	66
8	7.0	41	37	74	67
9	7.8	42	38	75	67
10	8.6	43	39	76	68
11	10	44	40	77	69
12	11	45	40	78	70
13	12	46	41	79	71
14	13	47	42	80	72
15	13	48	43	81	73
16	14	49	44	82	74
17	15	50	45	83	75
18	16	51	46	84	76
19	17	52	47	85	77
20	18	53	48	86	77
21	19	54	49	87	78
22	20	55	49	88	79
23	21	56	50	89	80
24	22	57	51	90	81
25	22	58	52	91	82
26	23	59	53	92	83
27	24	60	54	93	84
28	25	61	55	94	85
29	26	62	56	95	85
30	27	63	57	96	86
31	28	64	58	97	87
32	29	65	58	98	88
33	30	66	59	99	89
				100	90

NOTE: 1. Values for 10 through 100 knots are given to the closest whole knot.

2. Based on: 1 statute mile/hour = .8684 knot
1 knot = 1.1516 statute miles/hour

2. Other Conversion Factors

Table A-II

Convert	To	Multiply by
Miles/hour	Feet/second	1.4667
Miles/hour	Feet/minute	88.
Knots	Feet/second	1.6889
Knots	Feet/minute	101.33
Feet/second	Miles/hour	.6818
Feet/second	Knots	.5921
Feet/minute	Miles/hour	.01136
Feet/minute	Knots	.00986

APPENDIX B

DESCRIPTION OF SOME CONTEMPORARY WIND MEASURING EQUIPMENTS

1. GENERAL

The objective of this appendix is to describe in general terms the principles of operation employed in wind measuring equipment currently used by the Army in field operations. For a comprehensive study of wind measuring principles, techniques, and applications, reference is made to the publications listed in Section 4 of the basic MTP.

2. HAND-HELD WIND MEASURING UNITS

These units are complete instruments consisting of the wind speed and direction sensing-indicating elements mounted on a pistol-grip type handle.

a. The simplest example of this class is held in a vertical position and rotated in azimuth until an air-foil vane pivoted on top of the assembly is positioned by the wind to coincide with a fixed index mark. Wind direction is then read on a floating-ball magnetic compass which is a part of the unit. This orientation positions an orifice in the body into the wind, admitting the moving air into a channel to impinge upon a pivoted pressure plate. The pressure plate movement is directly coupled to the pointer of an enclosed meter having a dial graduated in knots. Thus the pressure plate and pointer displacement is directly proportional to the wind speed. High or low speed ranges are provided for by changing the size of the orifice.

b. A variation of the hand-held instrument type indicates wind direction by means of a tail vane-balanced arm element rotatable through 360 degrees on a vertical axis. In use, the entire unit is first aligned on a distant, fixed point of known direction by means of a sighting device on the body. Wind direction is then indicated in degrees from the known azimuth by the position of a pointer on the vane arm relative to a fixed 360 degree dial on the body. Wind speed is measured by a 3-blade vertical turbine driving a small AC generator and voltmeter, all mounted as the topmost components of the assembly. The voltmeter is graduated in knots since the generator output voltage is directly proportional to the turbine speed and therefore the wind speed. Change of speed range is effected by changing the voltmeter range through operation of a trigger-type switch.

3. SEMI-FIXED WIND MEASURING SETS/SYSTEMS

This general class of portable/transportable, remote indicating/recording wind measuring equipment is illustrated schematically in Figure 1 of the basic procedure. The various component types and the principles of operation are grouped herein first according to the functional chain, i.e., wind speed and wind direction and second, by the function within each chain, i.e., sensors, transducers, indicators, and recorders. Although treated separately in this description, it should be borne in mind that some elements of the two chains are combined into a single unit in some systems, for example: the speed and

direction sensors may be combined in the form of a windmill or a wingless, propeller-driven model aircraft mounted on a vertical shaft, the propeller responsive to wind speed and the vertical stabilizer (tail) responsive to wind direction and in addition serving to keep the propeller headed into the wind.

a. Wind speed components

1) Sensors are almost exclusively of the rotary or rotatable impeller type mounted with the associated transducer as a unit on a mast or similar support. Examples are:

a) the multiple blade propeller on a horizontal shaft.
b) the multiple blade turbine on a vertical shaft.
c) The free-spinning cup type on a vertical shaft.
d) The restrained or bridled cup type on a vertical shaft (a cup variant wherein wind action on multiple cups mounted on the periphery of a horizontal wheel tend to move the wheel against spring action. Wheel position from rest through one full revolution indicates wind speed from zero to design maximum).

2) Transducers are the electromechanical components driven (or positioned*) by the impeller through direct mechanical coupling. The electrical output signals are directly proportional to impeller speed (or position*) and therefore to wind speed. Examples are:

a) AC generator.
b) DC generator.
c) Light beam chopper and associated circuitry (creates DC pulses; pulse frequency conversion to analog DC proportional to impeller speed).
d) *synchro transmitter (used with the "bridled" impeller; 3-phase output signal characteristics vary with shaft position).

3) Indicators. Transducer output signals are transmitted to electrically compatible remote indicators via appropriate lengths of cable. Examples are:

a) AC or DC voltmeters or ammeters whose dials are graduated in knots or miles per hour.
b) A dial-type meter comparable to the above in external appearance except the pointer/needle is coupled to the shaft of a synchro receiver (used with synchro transmitter* above).

4) Recorders generally are the conventional clock-driven roll chart type employing an inked pen driven by a meter movement

or synchro receiver which is the calibrated equivalent of the indicator. Printed chart paper is graduated laterally in wind speed units and longitudinally in minutes, hours or days according to the preset chart transport speed. Recorders may be used in conjunction with or in lieu of the indicators.

b. Wind direction components

1) Sensors are generally of the tail vane-balanced arm type mounted on a vertical shaft which is free to rotate throughout 360 degrees. The shaft housing is mounted on a mast and is provided with some form of direction reference marking, i.e., north-south-east-west or an azimuth scale, as an aid in orienting the unit.
2) Transducers are directly coupled to the sensor shaft and produce signals indicative of shaft position (wind direction) relative to the housing orientation. Examples are:

a) A rheostat or potentiometer which varies a direct current by means of the sensor-positioned wiper arm.
b) A synchro transmitter.

3) Indicators employed with potentiometer transducers are essentially ammeters. However, since the meter cannot indicate over a full 360 degrees, two scales are provided which are read in conjunction with a scale switching feature. Indicators used with synchro transducers are the same as the wind speed synchro indicators except that the dial scale is graduated in degrees azimuth over the full 360 degree range.
4) Recorders are essentially identical to the wind speed recorders except for the calibration and chart scale factors described for the equivalent indicators above.

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13 ABSTRACT

This Engineering Test Procedure describes test methods and techniques for evaluating the technical performance and characteristics of Meteorological Equipment (Surface Wind Measuring). The evaluation is related to criteria expressed in applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other appropriate design requirements and specifications.

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